

Somatologic characteristics of biathlon students' body constitution in predicting of their successfulness

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Abstract

Purpose: determination of somatologic characteristics of biathlon students' body constitution in predicting of their successfulness.

Material: in the research the following students participated (n=27, age 19–21 years, boys n=17, girls n=10). Quetelet's, Erismann's and Piniel's anthropometric indices were calculated as well as life index.

Results: the greatest distinctions between boys and girls were observed by the following absolute indicators: body, trunk and torso lengths; body mass. The least distinctions were by the length of upper and lower limbs, which prevail in boys. In girls we observed noticeable realization of diaphragm breathing. It permits to increase alveolar surface at the cost of lungs' stretching in longitudinal direction. With it, there was no visible change of chest excursion. Relatively high level of women's physical fitness conditions asthenia (dolymorphia). It results in approximation of girls' chest shape to men's. In boys formation of somatic type is realized at the cost of chest circumferential sizes but directly depends on the strength of hands' and back's muscles.

Conclusions: for some sport-pedagogic activities (in our case – biathlon) certain type of body constitution is intrinsic, which conditions successfulness of professional program realization. Somatic type characterizes compliance and correlation of separated body links. These criteria permit to reduce costly part of future specialist's training and achieve high results in professional activity.

Keywords: somatology, somatic type, body constitution, body proportions, biathlon.

Introduction

Sport-pedagogic perfection is a necessary component, ensuring training of full fledged specialist. The uniqueness of this process implies applied character of tasks, which shall be solved by physical culture specialist in all kinds of his/her activity. It is an essential component of biathlon student's, as elite sportsman, practical activity [13, 16]. Professionalism of specialist depends on complex of factors, which condition the forms and content of his/her future sport-pedagogic activity. One of factors of such activity's successfulness is sport qualification, as determining factor of high sportsmanship, education and perfection. It will permit for a specialist to use wide spectrum of means, methods and forms. With it, somatologic characteristics of body type are decisive for achievement of high sport results and success in sport-pedagogic activity.

Retrospective analysis of the studied problem points at diverse approach to its studying. It is determination of correlations between somatic type components and their influence on the type of body constitution. It conditions achievement of high sport result and determines success in sport pedagogic activity in groups of appropriate specialization.

Scientists define the type of body constitution in compliance with sport specialization. But they do not regard the degree of correlations between somatic type components and their influence on success in professional activity, for example, when studying correlations between skiers' morphological parameters and sport results in sprint. Actually scientists regard athletes' successfulness in definite kind of program. They point at high level of correlations between physical condition indices, flexors/

extensors muscles, strength of body constitution and sport results. When studying boys-skiers' morphological characteristics, researchers found substantial increase of main anthropometric indicators from mesomorphic type to ecto- and mesomorphic balanced type. They note that for certain type of body constitution correlation of muscular/bone component, in compliance with type of functional reacting ("sprinter", "mixed", "stayer") is characteristic [3; 4].

Human phenotype is conditioned by complex interaction of inherited and acquired experience in conditions of certain environment that determines completeness of program's realization [6, 17]. Most of human organism's somatologic characteristics are genetically determined. It permits to predict successfulness of professional (sport-pedagogic) activity's realization. This aspect of human body constitution's study is of great theoretical and practical interest: theoretical – for general morphology of man – in connection with correlation of body functions and shape. Practical aspect means perfection of sport-pedagogic process. The purpose of this process is to find correspondence of body constitution with achievement in different kinds of sports as well as optimal dosing of loads at trainings [1, 10, 11].

Study of elite athletes' morphological characteristics permits to create anthropometric profile and separate somatologic features, which permit to perfect training and selection in different kinds of sport-pedagogic activity [10, 12].

In other works successfulness factors in sport activity were regarded in the following directions:

- Correlations of students' morphological functional indicators and their influence on sportsmanship level [26, 34, 35];
- Optimization of physical loads [18, 25];

- Consideration of students' individual features [20, 21];
- Finding of vertical jump's correlations with anthropometric sizes of athletes' bodies. Knowledge of these factors can help in identifying of talents and/or optimization of athletes' training [19];
- Improvement of physical training program for motorsport athletes. The authors found influence of main physiological parameters on predictors of motor-racing athletes' success at elite level [22];
- Finding of correlation between anthropometric profile and athletes' maximal strength in power-lifting. These results also support the opinion that power-lifters have unique anthropometric parameters. More successful power-lifters have greater muscular mass in respect to unit of height and/or bone mass [31];
- Study of detail anthropometric characteristics of elite female volleyball players. The authors found correlations between biomechanical parameters of lower limb power and jump height. These data were supplemented by anthropometric indicators of volleyball players' bodies. This knowledge permits for coaches to individualize and determine appropriate methods of training depending on somatic bent of female volleyball players [33];
- Analysis of body posture and constitution of martial arts athletes. The authors tried to create "model of champion", whose parameters determine efficiency in Thae-quan do. The authors note that sport potential and chances for success can be found on the base of athlete's posture and somatic type [28, 36]. Such approach permits to find the following criteria: talent for martial arts and self defense [29]; prediction of sport level at stages of Judo training [27];
- Proper distribution of training means and load. The author notes that it is necessary to uniformly distribute and dose correlation of means with all indicators of general and special physical training. It will ensure rising of athlete's sport results [23].

Of not less importance is solution of problems of students' health improvement, including body constitution components. It can be facilitated by proper pedagogic control over health indicators. In this contest we can mention the works, which permit:

- Optimize health components in compliance with requirements of future professional activity [37];
- Find directions of students' health improvement [32, 38, 39];
- Organize proper pedagogic control over motor indicators and somatic type components [24, 30];

In literature there are nearly no data about correlation of biathlon sportsmen's body constitution components in respect to their type in sex-age aspect, which ensure success in professional activity. It conditions the relevance of such scientific research. Such principles envisage creation of anthropometric model characteristics of students – members of sport-pedagogic perfection groups. All these reflect the specificity of future physical culture, sports and health specialists' professional activity.

The purpose of the research is determination of somatologic characteristics of biathlon students' body constitution in predicting of their successfulness.

Material and methods

Material: in the research the following students participated (n=27, age 19–21 years, boys n=17, girls n=10), who attend group of biathlon sport-pedagogic perfection. All students are members of National combined teams of Ukraine and Chernigov region. All they are elite athletes.

Organization of the research: total sizes of athletes' bodies were studied by standard methodic of indicators' registration: length of body and separate segments (torso, trunk, upper and lower limbs); body mass; chest circumference (CC) in rest, inhale and exhale; vital capacity of lungs (VCL); strength of hands and back muscles [2, 7, 14, 17]. Body length was measured with height meter. Other lengths were measured with the help of anthropological meter. The athlete's initial position was upright standing on floor. In projection value (the shortest distance between anthropometrical points) we registered the position of skeletal points in respect to the floor [6, 9].

With the help of empiric equations we calculated anthropometrical indices of Quetelet, Erisman, Piniet and life index (as relation of vital capacity of lungs to body mass, ml/kg^{-1}). Besides, we calculated relation of back and hands strength to body mass (%) [14].

Statistical analysis: statistical processing of the received data was fulfilled with the help of Microsoft Office Excel program [8]. For quantitative measurements we used such statistical characteristics as: mean arithmetic (M); standard error of mean arithmetic (m). Confidence of differences was estimated with Student's t-test for independent samples and U-test of Manna-Whitney (level of statistical significance $\alpha = 0.05$). When interpreting inter-correlations' matrixes we considered confident coefficients with diagnostic ($r \geq 0.3$) and prognostic ($r \geq 0.7$) value.

Results

Analysis of students' anthropometric status showed that there are no confident dependences of the studied components on qualification and insignificant correlation ($p \leq 0.05$) with training experience. Samples are rather homogenous and reflect inter sex distinctions within one specialization. The greatest differences between boys and girls were by absolute indicators of body, trunk, torso length and body mass. These indicators vary within 6.87 – 11.89%: the least are by the length of upper and lower limbs (5.00 – 5.14%) with prevailing such characteristics in boys (see table 1).

With it VCL indicator differs to the largest extent and is 27.19%. There are insignificant distinctions of CC in relative rest (at inhale and exhale – 2.83 – 3.09%) and chest excursion (0.57%) (see table 1). It is quite logical that CC can not be the criterion for comparison in sex aspect. More confident and expressive is indicator of chest excursion, reflecting individual's breathing function. This indicator

Table 1. Somatologic indicators of students – members of biathlon sport-pedagogic perfection group

Indicators	Boys (M±m)	Girls (M±m)	Δ,%
Age (months)	231,24±21,16	223,10±14,48	-3,52
Body area, m ²	1,83±0,09	1,63±0,04	-10,93
Body length, cm	176,64±4,88	164,50±3,30	-6,87
Trunk length, cm	84,50±2,51	77,04±4,00	-8,83
Torso length, cm	59,26±2,68	55,12±1,16	-6,99
Body mass, kg	66,84±4,70	58,89±1,95	-11,89
Lower limb's length, cm	88,43±3,89	84,01±3,86	-5,00
Upper limb's length, cm	73,00±3,47	69,25±3,70	-5,14
Maximal force of hand F _{max} (k), kg	46,65±4,57	33,10±4,70	-29,05
Maximal force of back F _{max} (k), kg	123,82±12,56	91,50±13,10	-26,10
VCL, ml	4623,24±600,69	3366,00±323,20	-27,19
In relative rest, cm	93,59±3,73	90,75±3,35	-3,03
Chest circumference			
At maximal inhale, cm	97,56±3,42	94,80±3,46	-2,83
At maximal exhale, cm	90,50±3,18	87,70±3,50	-3,09
Chest excursion, cm	7,06±1,78	7,10±1,50	0,57
Body mass/body area, kg·m ⁻²	36,37±1,06	36,05±1,27	-0,88
Upper limb's length /Lower limb's length, %	82,63±3,12	82,86±5,30	0,28
Upper limb's length/torso length, %	123,42±5,56	125,85±8,03	1,97
Lower limb's length/torso length, %	149,64±7,62	152,59±8,75	1,97
Lower limb's length/body length, %	50,05±1,42	51,05±2,04	2,00
Upper limb's length/ body length, %	41,32±1,54	42,10±1,89	1,89
Lower limb's length/trunk length, %	74,33±1,68	75,73±1,43	1,88

characterizes morphological-structural condition of chest, its mobility and breathing type. Chest excursion depends on its shape and girdle muscles' condition. It is restricted by weakness of breathing muscles [5].

Insignificant distinction of this characteristic in boys and girls points at similarity of their chests and somatic type. It characterizes kind of sport-pedagogic activity, realized in aerobic conditions. With it, there is no necessity in high mobilization of forced breathing movements, which are intrinsic to power and speed-power kinds of sport functioning. It is quite clear that cyclic exercises form better rhythm of organism systems' functioning. It implies breathing movements in combination with muscular efforts of upper and lower limbs. It is aerobic type of energy supply. Its purpose is; maximally quick elimination of oxygen debt, when fulfilling specific physical exercises; regulation of breathing movements on firing line (pointing and shooting). All these require athlete's maximal control over breathing movements.

It is interesting that boys' VCL differs significantly (27.19%) from girls'. Boys have advantage. There is

insignificant difference in correlation of body area to its mass (0.88%) (see table 1). It can witness about better diaphragm breathing of girls.

We confirmed that girls have less weight-height index by Quetelet (by 5.21%) with relatively higher index of chest proportionality by Erisman (by 61.29%) (see table 2).

Boys have greater values of hands' and back's relative strength (19.43% and 16.20% accordingly) that characterizes specificities of physical condition. Boys' body area significantly exceeds the girls' one (10.93%) with insignificant (0.88%) body mass. It witnesses about similarity of biathlon boys' and girls' body composition.

By Piniot's index boys and girls have similar values (19.30 – 17.91 conv.un.) Both boys and girls have normosthenic type of body constitution (mesomorphia) [6]. But, with it, girls have higher proportionality coefficient (by 4,95%). It can point at higher location of body center, comparing with boys. It is proved by the data of correlation of lower limbs' length with body, trunk and torso lengths, i.e. girls' lower limbs are longer in this

Table 2. Somatologic indices of students – members of biathlon sport-pedagogic perfection group

Indicators	Boys (M±m)	Girls (M±m)	Δ,%	
Quetelet's index, $g \cdot cm^{-1}$	377,92±19,16	358,22±16,26	-5,21	
Erisman's index, <i>conv.un.</i>	5,27±3,63	8,50±4,50	61,29	
Piniet's index, <i>conv.un.</i>	19,30±5,20	17,91±7,11	-7,20	
Coefficient of body proportionality, <i>conv.un.</i>	92,30±5,22	96,87±8,92	4,95	
"Life index", $ml \cdot kg^{-1}$	69,15±6,85	57,20±5,77	-17,28	
Power index, <i>conv.un.</i>	$(F_{max} \text{ hand, kg} \times \text{body mass}^{-1}, \text{kg}) \times 100$	69,90±5,29	56,32±8,26	-19,43
	$(F_{max} \text{ back, kg} \times \text{body mass}^{-1}, \text{kg}) \times 100$	185,90±21,89	155,78±22,58	-16,20

correlation. Alongside with it, wide chest is characteristic for girls' body constitution. It can be a compensating factor, which neutralizes higher body center by wider chest.

Analysis of somatologic indices' correlations with some indicators shows certain regularities of correlations of physical condition's components. It is quite logical that with one and the same bone mass Quetelet's index can vary at only at the accounts of greater/less mass of fat or muscular tissue. Muscular tissue is relatively "heavier" per unit of area in contrast to fat tissue. We can affirm that in sportsmen bigger/less values of index point at bigger/less level of muscular development. Higher values of index (by 5.21%) can witness about greater muscular mass in boys. This conclusion is confirmed by calculation of indices, which reflect relative strength of back and hands' muscles. By these indices boys exceed girls by results of dead lift and hand dynamometry (accordingly by 16.20% and 19.43%) (see table 2).

Discussion

Training of future physical education specialist is a multi-profile, specially organized process. It is facilitated by student's sport-pedagogic perfection. Student-biathlonist shall: develop and improve special physical and psychic qualities; master certain motor skills, specific for this kind of sport-pedagogic activity. Besides, there appear the problems, connected with students' individual features. All these shall be considered in planning and realizing training in groups of sport-pedagogic perfection [9, 20, 21]. For certain kind of sport-pedagogic activity (in our case – biathlon) definite type of body constitution is intrinsic, which conditions successfulness of professional program realization. Somatic type characterizes conformity and correlation of separate body segments. These criteria permit to reduce costly part of future specialist's training and achieve high results in professional activity. Such affirmation is extremely relevant in applied skiing – biathlon. Biathlon combines high level of physical potentials and skills with static-dynamic function. This function is realized in shooting on firing lines, sport orientation and sport selection. Specific

characteristics of posture are one of indicators, which influence on achievements in competition activities. That is why mainly athletes, who have morphological bent to definite kind of sports, win competitions [10, 27, 33]. Anthropometrical indicators, somatic type and body proportions permit to determine athlete's sport suitability and prospects even at initial stages of many years' training.

Distinctions in formation boys' and girls' Quetelet's index mean diverse influence of somatic-metric indicators: in boys index value is influenced by body mass and length in direct proportion; in girls there is significant correlation of body mass and CC (see fig. 1). The mentioned confirms the assumption about wide chest of girls and points at prevailing of their chest circumferential sizes over cross sizes, combined with high location of body center. This index is directly connected with chest circumference (CC in different position of measurements) and hand dynamometry as well as VCL. It witnesses about location of powerful muscular groups in upper part of boys' torsos. It conditions significant manifestation of muscular efforts of upper limbs and mobilization of chest breathing type. In girls there happens certain mobilization of diaphragm breathing type.

This conclusion confirms index of Erisman, which is the criterion of chest proportionality. The index is composed of CC parameters in rests state and body length. Body length influences on the index insignificantly. This index is formed by chest circumference with significant or insignificant negative correlation of hand and back strength (see fig. 2). It witnesses that increase of physical fitness (in particular power) results in narrowing of chest. It is a sign of biathlon girls' morphological masculinization. Increase of girls' muscular strength results in reduction of chest volume.

In boys this index is formed at the account of CC and insignificantly at the account of body length. We did not find any confident correlations of the index with strength of hand and back. It points at high level of chest formation. Increase of physical fitness does not result in noticeable changes of chest volume.

Analysis of body constitution type (by Piniet's index) shows that CC is a determining factor in formation of

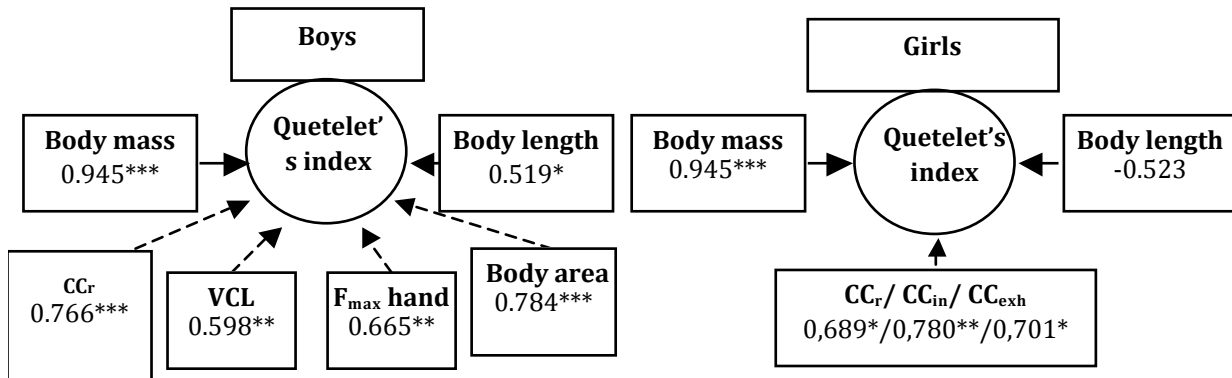


Fig.1. Interconnection of Quetelet's index with somatologic indicators of students – members of biathlon sport-pedagogic perfection group. CC_r – chest circumference in rest; CC_{in} – chest circumference at inhale; CC_{exh} – chest circumference at exhale;

—> indicators, which compose index;

- - -> indicators, which influence on index;

* - statistic significance of Pirson's correlation coefficients at $p \leq 0.05$;

** - statistic significance of Pirson's correlation coefficients at $p \leq 0.01$;

*** - statistic significance of Pirson's correlation coefficients at $p \leq 0.001$

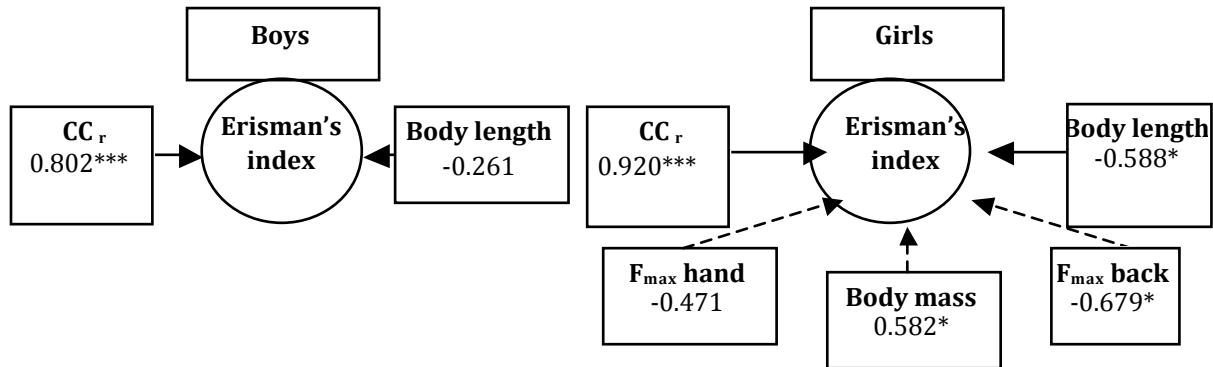


Fig. 2. Interconnection of Erisman's index with somatologic indicators of students – members of biathlon sport-pedagogic perfection group. CC_r – chest circumference in rest;

—> indicators, which compose index;

- - -> indicators, which influence on index;

* - statistic significance of Pirson's correlation coefficients at $p \leq 0.05$;

** - statistic significance of Pirson's correlation coefficients at $p \leq 0.01$;

*** - statistic significance of Pirson's correlation coefficients at $p \leq 0.001$.

somatic type and influences on index in reverse proportion: the less body mass and CC are, the higher is asthenicity (dolymorphia) of students and it is quite natural (see fig. 3).

It is characteristic that in girls, body length positively ($p \leq 0.05$) influences on index. In boys the strength of body constitution is positively influenced by indicators of back and hands' muscles' power as well as VCL. Correlations are not confident. They point at certain tendency of influence on somatic type's formation. Besides, they witness about relatively lower values of VCL, strength of back and hands in asthenic type persons. In girls this tendency has reverse character – asthenic body constitution is determined by relatively high strength of muscles. It is a proof of the assumption about masculinization of girls' body constitution: relatively high physical fitness (power, in particular) conditions asthenicity (dolymorphia) and results in chest shape approximation to men's chest. With

it, girls' body length is a dependent variable. In boys, longitudinal sizes of body do not substantially influence on asthenicity/normosthenicity/hypersthenicity of body constitution. Somatic type formation is realized at the account of chest circumference (CC in different position of measurements and chest excursion) and depends on back and hands strength (see fig. 3).

Analysis of "vital index" values shows this attribute's noticeable advantage (by 17.28%) in boys (see table 2). The character of dependences on other anthropometric indicators is rather ambiguous (see fig. 4). This index has high direct correlation with VCL ($p \leq 0.001$) with not confident correlation with body mass. In boys the value of this index substantially ($p \leq 0.01$) positively depends on chest excursion with not confident correlation with CC at inhale. This fact proves assumption about chest breathing's prevalence in boys. In girls this tendency is absent and change of index is negatively influenced by

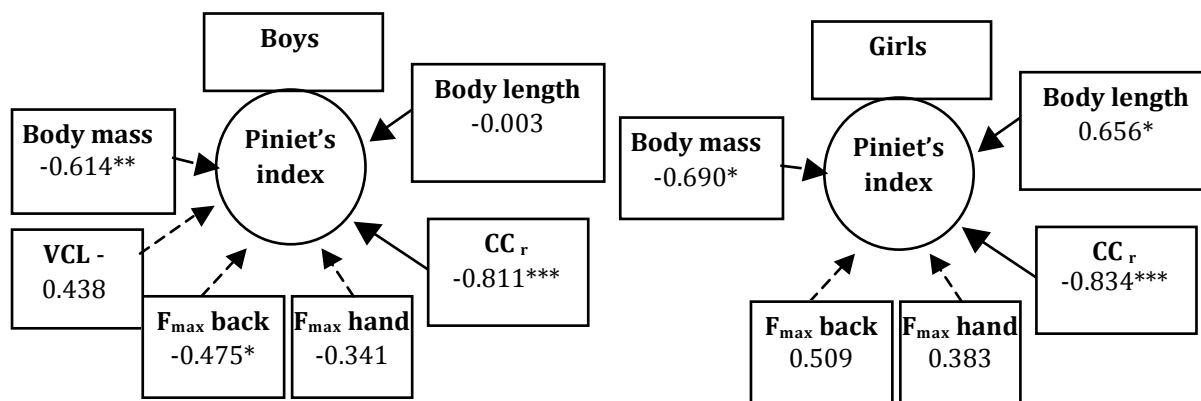


Fig. 3. Interconnection of Piniet's index with somatologic indicators of students – members of biathlon sport-pedagogic perfection group. CC_r – chest circumference in rest;
 —> indicators, which compose index;
 —> indicators, which influence on index;
 * - statistic significance of Pirson's correlation coefficients at $p \leq 0.05$;
 ** - statistic significance of Pirson's correlation coefficients at $p \leq 0.01$;
 *** - statistic significance of Pirson's correlation coefficients at $p \leq 0.001$.

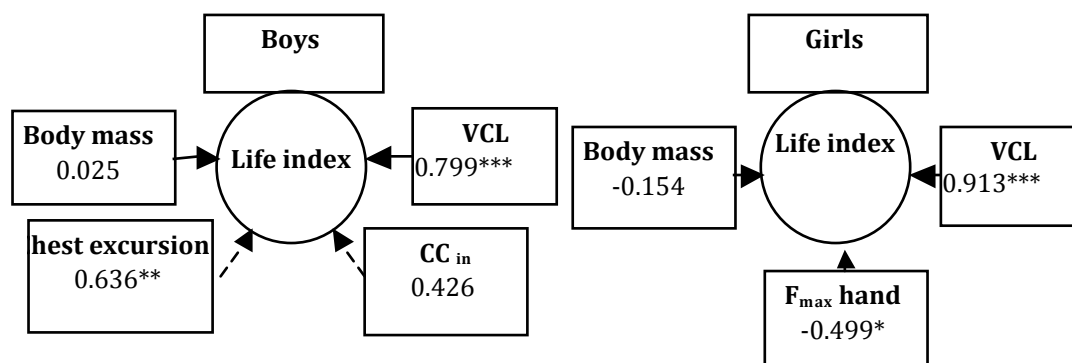


Fig. 4. Interconnection of life index with somatologic indicators of students – members of biathlon sport-pedagogic perfection group. CC_{in} - chest circumference at inhale;
 —> indicators, which compose index;
 —> indicators, which influence on index;
 * - statistic significance of Pirson's correlation coefficients at $p \leq 0.05$;
 ** - statistic significance of Pirson's correlation coefficients at $p \leq 0.01$;
 *** - statistic significance of Pirson's correlation coefficients at $p \leq 0.001$.

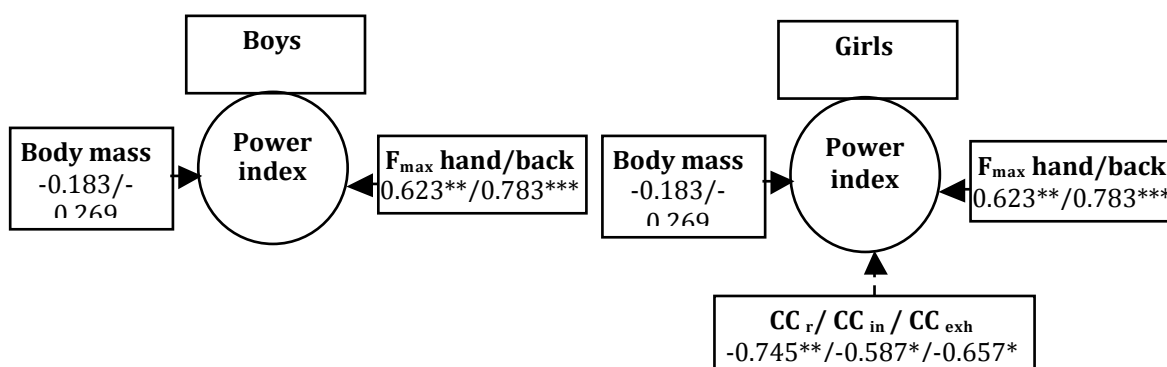


Fig. 5. Interconnection of power index with somatologic indicators of students – members of biathlon sport-pedagogic perfection group. CC_r - chest circumference in rest; CC_{in} - chest circumference at inhale; CC_{exh} - chest circumference at exhale;
 —> indicators, which compose index;
 —> indicators, which influence on index;
 * - statistic significance of Pirson's correlation coefficients at $p \leq 0.05$;
 ** - statistic significance of Pirson's correlation coefficients at $p \leq 0.01$;
 *** - statistic significance of Pirson's correlation coefficients at $p \leq 0.001$.

hands strength (see fig. 4).

The character of dependences between students' power potentials' indices is proved by the following tendencies: the main combining factor is strength of back/hand muscles with absence of confident dependence on body mass. It can be an evidence of high physical fitness level, which are phenotypically determined as a result of sport-pedagogic activity (see fig. 5).

In most of other faculties' students (in contrast to physical education faculty) classes of sport-pedagogic, sport-mass or/and recreation activity are absent. In this students perfection of physical condition is fulfilled by means of physical culture. In these students index value has confident dependences on physical fitness (power, in particular) and on anthropometric characteristics [15, 23]. Characteristic distinction of girls' power index is negative correlation with CC in different positions of measurements. In boys such correlations are absent. This tendency confirms our assumption about formation of masculinization in biathlon girls. It results in mobilization of diaphragm breathing.

Conclusions:

1. The highest differences between boys and girls are observed by absolute indicators of body, trunk, torso lengths and body mass. The least differences are observed by the length of upper and lower limbs and these signs prevail in boys. In girls diaphragm breathing is noticeably realized. It permits to increase alveolar area at the cost of longitudinal stretching of lungs. With it no noticeable change of chest excursion is observed.

2. In boys there are higher values of relative power of back and hands that characterize specific features of men's physical condition. In girls we observed relatively wide chest, combined with high location of body center.

3. Relatively high physical fitness of girls (power, in particular) conditions asthenic/normosthenic/hypersthenic body constitution. Somatic type's formation is realized at the account of chest circumference and directly depends on hands' and back strength.

4. The received result is a peculiar model, which witnesses about opportunities for more successful sport activity.

Conflict of interests

The authors declare that there is no conflict of interests.

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